
Name of Organization: University of MI - School of Public Health

Type of Organization: College or University

Contact Information: Dr. Stuart Batterman
Department of Environmental Health Sciences
109 Observatory Drive
Ann Arbor MI 48109

Phone: (734) 763 - 2417 **Extension:**

Fax: (734) 764 - 9424

E-Mail: stuartb@umich.edu

Project Title: Modeling and Measurement of PBTs in Northern Michigan

Project Category: Pollution Prevention and Reduction - BNS

Rank by Organization (if applicable): 1

Total Funding Requested (\$): 147,000 **Project Duration:** 2 Years

Abstract:

Atmospheric deposition of persistent bioaccumulative toxics (PBTs) remains an important issue in the Great Lakes region, due to the heavy concentration of industrial activity and high historical releases of these compounds. Routinely detected in all environmental media, PBTs have been implicated in several public health and environmental problems, e.g., deformity, reproductive dysfunction and cancer in humans and wildlife. Twelve persistent organic pollutants (including Polychlorinated biphenyls (PCBs) and the insecticide dieldrin, have been targeted for virtual elimination under the U.S./Canada Binational Toxics Strategy. A joint U.S./Canada monitoring program, The Integrated Atmospheric Deposition Network (IADN), has measured concentrations of PBTs in air and precipitation in the Great Lakes region since 1990. Declines in measured levels have appeared to stabilize in recent years and current levels are believed to reflect atmospheric recycling and deposition, especially in remote areas. Using a joint modeling/monitoring approach, this research aims to model the transport, fate and bioaccumulation of selected PBTs (i.e, PCBs, dieldrin) in selected small lakes in remote areas in Northern Michigan. Contaminant measurements performed under the IADN program will provide initial model inputs. Modeling analyses will estimate the contributions of direct and indirect loading (catchment runoff) to concentrations in aquatic biota and the importance of soils and sediments as secondary sources. Modeling will also be used to forecast trends in PBT concentrations in fish and wildlife. Sampling and analysis of selected environmental media and aquatic biota will provide a basis for validation of the transport and bioaccumulation models. Probabilistic uncertainty analyses will be employed to assess the reliability of predictions and provide a basis for impact and risk assessments.

Geographic Areas Affected by the Project

States:

| | |
|----------------------------------------------|---------------------------------------|
| <input type="checkbox"/> Illinois | <input type="checkbox"/> New York |
| <input type="checkbox"/> Indiana | <input type="checkbox"/> Pennsylvania |
| <input checked="" type="checkbox"/> Michigan | <input type="checkbox"/> Wisconsin |
| <input type="checkbox"/> Minnesota | <input type="checkbox"/> Ohio |

Lakes:

| | |
|----------------------------------------------|------------------------------------|
| <input checked="" type="checkbox"/> Superior | <input type="checkbox"/> Erie |
| <input type="checkbox"/> Huron | <input type="checkbox"/> Ontario |
| <input checked="" type="checkbox"/> Michigan | <input type="checkbox"/> All Lakes |

Geographic Initiatives:

| | | | | |
|------------------------------------------|----------------------------------|-------------------------------------|--------------------------------------|-----------------------------------------|
| <input type="checkbox"/> Greater Chicago | <input type="checkbox"/> NE Ohio | <input type="checkbox"/> NW Indiana | <input type="checkbox"/> SE Michigan | <input type="checkbox"/> Lake St. Clair |
|------------------------------------------|----------------------------------|-------------------------------------|--------------------------------------|-----------------------------------------|

Primary Affected Area of Concern: Not Applicable

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area: Keweenaw Peninsula

Other Affected Biodiversity Investment Areas: Sleeping Bear Dunes

Problem Statement:

Atmospheric deposition and accumulation of persistent bioaccumulative toxics (PBTs) remains an important issue in the Great Lakes region due to high historical releases of these compounds. Routinely detected in all environmental media, PBTs accumulate in sediments and may biomagnify in food chains. PBTs have been implicated in a variety of health and environmental problems, e.g., deformity and reproductive impairment in wildlife, and reproductive and developmental impairment, cancer and neurotoxicity in humans. Twelve persistent organic compounds (including PBTs such as PCBs and dieldrin) have been targeted for virtual elimination under the U.S./Canada Binational Toxics Strategy. In addition to the Great Lakes themselves, numerous inland lakes and streams in the Lake Michigan and Lake Superior basins are under fish advisories for PCBs for sensitive populations such as women and children.

The Integrated Atmospheric Deposition Network (IADN) is a joint U.S./Canada monitoring program, founded under the Great Lakes Water Quality agreement. Since 1990, IADN has measured airborne PBT concentrations. IADN and other measurements have shown that concentrations in environmental media and biota have stabilized, and current levels are assumed to reflect release from large reservoirs to the atmosphere, followed by deposition and recycling. Although PBT deposition affects the entire landscape, its importance is more readily assessed in areas remote from point or area sources.

This research is designed to achieve several goals: (1) Model the transport and fate of selected PBTs (i.e, PCBs, mercury) in small lake catchments in two remote areas in Northern Michigan; (2) Model bioaccumulation in selected fish and fish-eating birds and mammals; (3) Forecast trends in PBT concentrations in fish and wildlife; (4) Monitor PBT concentrations in media and selected biota, to characterize trophic transfer and validate model predictions; and(5) Provide probabilistic human and ecological risk estimates of the importance of PBT exposure to humans and wildlife. The research will examine several hypotheses, including: (1) indirect loading from catchment sources equals or exceeds that from direct atmospheric loading to the lakes; (2) Soils and sediments have accumulated large pools and will act as secondary sources for the indefinite future; and (3) PBT concentrations in higher trophic levels will remain stable for the indefinite future. These hypotheses will be evaluated using a combined modeling and monitoring program.

Proposed Work Outcome:

Specific research tasks have been delineated below:

Study Areas. Several small lakes in the Sleeping Bear Dunes National Lakeshore and in the vicinity of Eagle Harbor on the Keweenaw Peninsula have been identified as study sites, due to their isolation from development and proximity to IADN

monitoring stations. Both areas provide habitat for a large number of bird and wildlife species and receive high angler use.

Lake Mass-Balance Model. PBT transport and fate will be modeled in the study areas using a mass-balance approach. Water and sediment concentrations will be estimated as the difference in potential inflows, e.g., atmospheric deposition and catchment runoff and potential outflows, i.e., streamflow, volatilization and deep burial.

Bioaccumulation Model. Concentrations in water and sediment from the lake model will serve as inputs to a bioaccumulation model, also using mass-balance concepts to represent concentration, ingestion, assimilation and elimination processes. Trophic transfer from plankton to predator fish, birds and mammals will be modeled, with intermediate levels represented by insects, crustaceans and fish.

Model Application. Steady-state models will be developed and applied to characterize PBT fate and food-chain relationships. Both models will be used to hindcast historical loadings and interpret monitoring results. The models will then be used to forecast long-term bioaccumulation in key biota and indicator organisms.

Sensitivity, Uncertainty and Validation. Sensitivity analyses will serve the dual purpose of identifying important variables and evaluating the sensitivity of lake and biotic concentrations to atmospheric loadings. Monte Carlo analyses will incorporate uncertainty to express model predictions as probability distributions. Predictions will also be compared to previously collected data and to measured concentrations in sampled organisms.

Biological Sampling and Chemical Analyses. Field sampling for organisms and media will be conducted, with chemical analyses performed at the USGS Great Lakes Science Center. Organisms in the food chain of top predator fish, e.g., salmonids will be targeted and used to represent defined trophic levels. Sampling schema will be designed to account for spatial and temporal variation in monitored variables. Finally, sampling in different compartments will be coordinated in time and space, to improve the utility of measurements for model validation.

Hazard and Risk Assessment. Levels of PBTs in sediments, water and tissue will be compared to criteria to estimate threshold exceedances. Probabilistic risk estimates will aid resource managers in determining whether wildlife are impaired and whether remediation is indicated and health officials in evaluating risk to exposed populations, i.e., anglers.

This research will be of value to Federal and State agencies in information gathering on the range of non-point sources of Level-I PBTs in the Great Lakes basin. In implementation of the "Total Maximum Daily Load (TMDL)" program under Section 303d of the Clean Water Act, these results will be of use to the Michigan Department of Environmental Quality (MDEQ) in generating quantitative estimates of background concentrations due to atmospheric loading in waters impaired by Level-I PBTs. Under this program, water bodies with fish advisories but no known sources are considered in nonattainment. TMDL development for PCBs and chlordane has been postponed until late in the process to allow for development of information concerning analysis at low-level concentrations expected in the environment.

In addition, these results will be of value to the Michigan Department of Community Health (MDCH) in administration of its Fish Consumption Advisory Program. These analyses would enable MDCH to account for the presence of PBTs in fish in remote areas and in assessing whether atmospheric deposition alone might be expected to result in risk to fish-consuming populations.

Project Milestones:**Dates:**

| | |
|-----------------------------------------|---------|
| Project Start | 09/2000 |
| Model design, data compilation | 03/2001 |
| Field Sampling, interim reporting | 09/2001 |
| Chemical analysis, Model validation | 03/2002 |
| Model application, uncertainty analyses | 06/2002 |
| Reporting, publication | 07/2002 |
| | / |
| Project End | 09/2002 |

☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

This research will comprise a doctoral dissertation research project for a Ph.D. student in Environmental Health Sciences, University of Michigan. The effort will require synthesis and application of knowledge from several disciplines. The research will also provide in-depth training in quantitative techniques such as numerical methods, distribution fitting, parameter optimization, model calibration and Monte Carlo uncertainty analysis. Another crucial and complementary component will be the collection, reduction, analysis and interpretation of primary data. Interaction with researchers and practitioners in several Federal and State agencies will also prove valuable. Work-Study students from the University of Michigan, Ann Arbor, and Student Authority Contract students from Eastern Michigan University, Ypsilanti, will assist with this project. Results will be published in primary scientific literature and also in USGS report series and outreach leaflets. Researchers will provide support to Sleeping Bear Dunes National Park in developing outreach materials for park visitors/general public to inform them of the relevance of these results.

Project Budget:

| | Federal Share Requested (\$) | Applicant's Share (\$) |
|----------------------------|-------------------------------------|-------------------------------|
| Personnel: | 62,000 | 63,500 |
| Fringe: | 14,000 | 0 |
| Travel: | 4,000 | 0 |
| Equipment: | 0 | 0 |
| Supplies: | 3,000 | 0 |
| Contracts: | 40,000 | 0 |
| Construction: | 0 | 0 |
| Other: | 2,000 | 0 |
| Total Direct Costs: | 125,000 | 63,500 |
| Indirect Costs: | 22,000 | 0 |
| Total: | 147,000 | 63,500 |
| Projected Income: | 0 | 0 |

Funding by Other Organizations (Names, Amounts, Description of Commitments):

Matching funds of \$31,000 in year one and \$32,000 in year two will be provided by the University of Michigan and the USGS Great Lakes Science Center in personnel salaries, facilities, and field equipment.

Description of Collaboration/Community Based Support:

The research will involve direct collaboration between the University of Michigan and the the US Geological Survey. Two of the investigators are research scientists with the US Geological Survey, and will provide expertise in several areas, i.e., field sampling of environmental media and aquatic biota, chemical analysis techniques and ecological risk assessment. The University researchers will provide expertise in model development, parameterization, calibration and uncertainty analyses. In addition to publication in professional literature, several USGS report series are potential venues for dissemination of results and products. The Park manager in Sleeping Bear Dunes initially identified this research and has offered to provide technical and logistic support during field operations.

Collaborators:

D.R. Passino-Reader, Research Fishery Biologist, USGS

J.P. Hickey, Research Chemist, USGS

D. Mendez, Professor, University of Michigan, EHS

J.E. Warila, Doctoral Candidate, University of Michigan, EHS